SCIENCE

NEW SERIES
VOL. XLVI. No. 1186

FRIDAY, SEPTEMBER 21, 1917

SINGLE COPIES, 15 CTS.
ANNUAL SUBSCRIPTION, $5.00

SCIENCE

FRIDAY, SEPTEMBER 21, 1917

CONTENTS

The Magnetic Field of an Atom: DR. W. J. HUMPHREYS 273

Kentucky as an Oil State: JAMES H. GARDNER. 279

Overwintering of the Apple-scab Fungus: DR. W. P. FRASER 280

Scientific Events:—

Baron Dairoku Kikuchi; The Production of Potash in the United States; The Museum of the Royal College of Surgeons of England; The Mayo Foundation and the University of Minnesota 282

Scientific Notes and News 284

University and Educational News 287

Discussion and Correspondence:—

On the Rawness of Subsoils: DR. CHAS. B. LIPMAN. *Northern Lights:* THOMAS BYRD MAGATH. *The New Moon:* DR. OTTO KLOTZ. *Erasmus Darwin and Benjamin Franklin:* PROFESSOR LORANDE LOSS WOODRUFF 288

Scientific Books:—

MacNutt on the Modern Milk Problem: PROFESSOR LEO F. RETTGER 292

Special Articles:—

Gravitational Repulsion: PROFESSOR FRANCIS F. NIPHER. *The Catalase Content of Luminous and Non-luminous Insects compared:* DR. W. E. BURGE. *The Effect of Smelter Gas on Insects:* R. W. DOANE 293

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y

THE MAGNETIC FIELD OF AN ATOM[1]

THE substance and structure of the atom, the movements of its parts, and its properties, are, perhaps, the most fundamental subjects of modern physical investigation. And although the structure and even the substance of the atom can as yet only be inferred, nevertheless its numerous and varied phenomena not only challenge the theorist, but also, through their manifold checks, afford him at every turn the very best guidance to an approximately correct inference. Among the more important of these phenomena are the actions of atoms in respect to absorption and emission of radiation under various conditions of temperature, pressure, magnetic and electric fields. Crystal forms, chemical reactions and magnetic properties offer additional suggestions and valuable tests.

One of the most interesting inferences concerning the atom is this: that it has a very powerful magnetic field. This inference is supported by a number of investigations of entirely different character which it is proposed in what follows to outline briefly and in approximately their chronological order.

1. The electromagnetic theory of ether vibrations so satisfactorily accounted for many known phenomena and so successfully predicted others, including wireless telegraphy, that it was long ago generally believed that all radiation, including light,

[1] Presented at the symposium on "The Structure of Matter" at a joint meeting of the Sections of Physics and Chemistry of the American Association for the Advancement of Science, The American Physical Society and the American Chemical Society, New York, December 27, 1916.

must have its origin in rapidly oscillating or orbitally moving electric charges whose periods are the same as the periods of the emitted radiation. Further, since spectral lines, except those belonging to bands, were found always to be characteristic of the elements and never of their compounds, it soon became evident that the corresponding radiations are of atomic and not molecular origin. Hence the natural conclusion that the atoms of all elements, for all give line spectra, are either associated with or consist, in part at least, of electric charges undergoing complete periodic changes of distribution or position at the rate obviously found by dividing the velocity of any given radiation by the corresponding wave-length, changes, therefore, in the case of green light, at the rate of some six thousand million million per second. Such numbers, of course, are appalling, but the logic is inexorable.

2. In 1885 Balmer[1] announced his remarkable though empirical series formula as applied to the visible hydrogen lines H_α H_β, H_γ and H_δ; that is

$$\frac{1}{\lambda} = N\left(\frac{1}{2^2} - \frac{1}{n^2}\right), \quad n = 3, 4, 5, \text{ etc.},$$

a formula that has since been found to give with great accuracy the wave frequencies of the whole hydrogen series of at least 35 lines. The same general formula, or some modification of it, such as Rydberg's,

$$\frac{1}{\lambda} = N\left(\frac{1}{a^2} - \frac{1}{(n+c)^2}\right),$$

gives with equal accuracy the wave frequencies of the lines of many other series of various elements.

Here, then, was a further important hint in regard to the structure of the atom, but for a long while no one interpreted what it meant.

[1] *Ann. der Phys.*, 25, 80, 1885.

3. In 1897 Lord Rayleigh[2] emphasized the fact that the vibrations producing spectral series hardly could result from ordinary elastic or electric forces of restitution since each of these gives equations involving squares of the frequencies—the displacement being expressed in terms of sin t/λ its acceleration involves the factor $1/\lambda^2$—while the Balmer and similar formulæ that so closely follow the lines as they actually occur contain only first powers of this term.

Although Lord Rayleigh's paper was essentially negative in respect to atomic structure, it nevertheless was an important contribution to this difficult subject in that it rendered well nigh untenable certain theories that appeared then to be more or less generally held, namely, all that compared the atom to an elastic sphere, parallelopiped, or other solid, and those alike that assumed it to be some unknown type of Hertzian oscillator.

4. In the meantime two other important spectroscopic phenomena were announced that at first seemed to render far more difficult any satisfactory interpretation of the atom and its structure. These were, *a*, the pressure displacement of spectrum lines, discovered by Mohler and the author[3] in 1895, and, *b*, the magnetic resolution and dispersion of such lines, discovered by Zeeman[4] in 1896.

5. About this same time investigations on electric discharges through gases, and analogous phenomena, became world wide, initiated mainly by the wonders of the X-rays and largely sustained by the frequent stimuli of new discoveries by Thomson, Rutherford, Madame Curie, and their brilliant associates.

Among the many important results of

[2] *Phil. Mag.*, 44, 356, 1897.

[3] *Astrophys. Jr.*, 3, 114, 1896.

[4] *Phil. Mag.*, 43, 226, 1897.

these numerous investigations are the discoveries that negative electricity occurs in multiples of a perfectly definite and accurately measurable unit; that this unit, the negative electron, perhaps in large numbers, is at least an integral part of all atoms; that electrons often are ejected from an atom; that when ejected they leave with enormous velocities; that when in motion they possess inertia; and that this inertia increases with the velocity.

Naturally such discoveries suggested the Saturnian and other similar atomic models, several of which have been elaborately discussed.

6. In 1906 the author[5] computed the possible magnetic field of a Saturnian atom and found in this field a vera causa, perhaps an adequate cause, of the hitherto unexplained pressure shift of spectral lines. A simple presentation of the argument is as follows:

Assuming Thomson's Saturnian atom of revolving rings of electrons, it seems probable that the wave frequency of the radiation emitted by any one of the rings of a given atom may be a simple multiple of its orbital frequency. Any bunching, for instance, of the electrons, however temporary, would produce radiation whose frequency was the same as that of the complete orbital revolutions. But this revolution of rings of electrons, presumably around a common axis, constitutes so many circular electric currents which obviously produce solenoidal magnetic fields, and themselves are subject to inductive effects.

Now it has been shown by Langevin[6] that in the case of a ring of electrons any forced change in the magnetic flux merely alters the orbital speed without changing the radius. Hence the self induction remains constant and if E be the induced electromotive force, then

$$E = L\frac{di}{dt} + Ri,$$

in which L is the self-induction, R the ohmic resistance and i the strength of the current. But in the case of an atomic ring of electrons $E = dN/dt =$ rate of change of magnetic flux through the ring, and $R = O$, presumably.

Hence

$$\frac{dN}{dt} = L\frac{di}{dt},$$

and

$$di = \frac{dN}{L}.$$

That is, the induced current in the ring is directly proportional to the change in the magnetic flux through it. Furthermore, the induced current is permanent instead of momentary as in ordinary circuits, so long as the change in N is permanent.

In this connection it is interesting to note that Kamerlingh Onnes[7] has recently shown by a series of brilliant experiments that an induced current may last for hours with but little reduction (less than 1 per cent. per hour) in a lead wire solenoid at very low temperatures.

Now, from the Zeeman effect it is obvious that radiating atoms are acted upon by an external magnetic field, and, therefore the inference is immediate that these atoms themselves possess magnetic fields of their own—*they could not otherwise be acted upon by a magnetic force.* Also, since the the kind and magnitude of the Zeeman effect is independent of temperature, as shown by both radiation and absorption, it follows that the atomic field must also be independent of temperature.

Further, as magnetic fields are known always to exist in connection with electric currents, and not certainly known ever to be due to any other cause, and as moving electrons constitute the only known electric

[5] *Astrophys. Jr.*, 23, 233, 1906.

[6] *Journal de Physique*, 4, 678, 1905.

[7] *Nature*, 93, 481, 1914.

current, it therefore will be assumed that the atom's magnetic field is due to orbitally revolving rings of electrons, subject to temporary bunchings or other disturbances, possibly the shift of an electron from one ring to another, that render the ring so disturbed, or the shifting electron, radiative during the brief interval in which equilibrium is being regained.

Let v be the velocity of light, λ the wavelength of the emitted radiation, ω the angular velocity of the electrons as seen from the center of the orbit, S the average strength of the enclosed magnetic field, K a constant and n a whole number, perhaps unity. Then

$$\frac{v}{\lambda} = \frac{n\omega}{2\pi} = KS. \quad (1)$$

Hence

$$\mp \frac{vd\lambda}{\lambda^2} = \pm KdS. \quad (2)$$

From (1) and (2)

$$\mp \frac{d\lambda}{\lambda} = \pm \frac{dS}{S}.$$

But dS is added to the fields of some atoms and subtracted from the fields of others by the application of an external magnetic field of strength H to any mass of gas. Hence

$$\mp \frac{d\lambda}{\lambda} = \frac{H}{S}.$$

By substituting H for dS in (2) we get

$$\frac{d\lambda}{H\lambda^2} = \frac{K}{v}, \text{ a constant.}$$

But this is the well-known Zeeman law, and therefore it appears that the assumed simple structure of the atom must at least crudely resemble its actual structure.

From the known values of H, λ and $d\lambda$ the computed value of S, the average strength of the atomic magnetic field, is of the order of 10^8 gauss.

Similarly from the probable size of the atom, radius $= 10^{-8}$ cm., and the charge of the electron it is easy to calculate the magnetic field at the center of the ring system on any definite assumption of the speed of rotation and number of electrons.

If it is assumed that the period of rotation is the same as that of the emitted radiation, and that N, the number of electrons in the atom, is of the order

$$N = A\ 10^8$$

in which A is the atomic weight, a number many investigators regard as probable, then the computed intensity of the magnetic field at the center of an iron, titanium, or other such atom is of the order of 10^8, roughly 2,000 times the most intense field yet produced between the poles of electromagnets.

Whatever the strengths of these fields, each atom must act inductively on all its neighbors and in turn be acted upon by them, to an extent that for each couple varies approximately as the cube of the distance between their centers. If two atoms in the turmoil of the electric arc, for instance, chance closely to approach with similar poles facing each other their mutual induction will be such as to increase the speed of their electrons, and thus for the instant slightly to shift their spectrum lines to the violet. If, however, they approach with opposite poles facing each other the shift will be to the red. But in the second case the atoms clearly will come closer together, thus producing stronger inductions and greater shifts, than in the first. Hence the net result is a displacement of the maximum intensity of the line to the red.

When the gas pressure about the light source, an electric arc, suppose, is low the distance between neighboring atoms is relatively large and therefore during only a correspondingly small fraction of the time is any given atom under the strong inductive influence of others. During the rest of the

time the frequency of its vibration is undisturbed. Hence the spectrum lines given out by rarefied gases, in which an atom is only "occasionally" close to another, are comparatively clean and sharp. With increase of pressure the free path is decreased and the total interval of disturbance lengthened to practically the same fractional extent. If, for instance, the pressure is doubled, temperature remaining constant, the free path is halved, atomic "collisions," total duration of an atom's close proximity to others, and, therefore, quantity of shifted light all are at least doubled. Hence with increase of pressure a spectral line must spread (independent of the Doppler effect) and its maximum intensity shift to the red.

Under very heavy pressures the atoms are always within mutually disturbing distances, and therefore under such conditions their lines gradually merge into a continuous spectrum.

It might seem that atoms with such strong magnetic fields necessarily would cluster into rods and rings, like iron filings in a magnetic field. In short, that at any attainable temperature, a gas consisting of such atoms would collapse into—who knows what?

To test this point consider an extreme case. Let two atoms, each consisting of a single circular ring of 5×10^4 electrons and an equivalent positive nucleus at its center, face each other on a common axis, and let the orbital revolution of their rings have the frequency of yellow light of wavelength $.6\mu$: Find the electric and magnetic forces between them.

The magnetic flux through either ring due to the presence of the other is given by the expression

$$N = \frac{2\pi^2 i r^4}{(r^2 + x^2)^{3/2}},$$

in which i is the strength of the current, r the radius of the ring, and x the distance between the centers. Hence the magnetic force between the rings is found by the equation

$$F_{\text{magnetic}} = 2\pi^2 i^2 r^4 \frac{d}{dx} \frac{1}{(r^2 + x^2)^{3/2}} = \frac{6\pi^2 i^2 r^4 x}{(r^2 + x^2)^{5/2}}.$$

Assume the electronic charge to be 4.774×10^{-10}, Millikan's value, and let $r = 10^{-8}$ cm. Then when

$$x = r,$$
$$F_{\text{magnetic}} = 1.6561 \text{ dynes},$$

$$10r \qquad\qquad 100r$$
$$91.39 \times 10^{-5} \text{ dyne}, \quad 9.37 \times 10^{-8} \text{ dyne}.$$

The electric force between the two atom models consists of four parts; namely, attraction between each nucleus and its neighbor's ring, repulsion between the nuclei and repulsion beween the rings. The problem of computing this force is not so simple as, at first sight, it is likely to appear. However, a general solution of the problem of the rings (rings of different radii and linear densities) in the form of a converging series has been kindly furnished by Professor R. S. Woodward. A similar solution of the somewhat simpler problem presented by duplicate atom models gives the following total electric forces (repulsions) between them:

$$x = r,$$
$$F_{\text{electric}} = 3578 \times 10^3 \text{ dynes},$$

$$10r \qquad\qquad 100r$$
$$34.186 \text{ dynes}, \quad 6.45 \times 10^{-8} \text{ dyne}.$$

Of course it is not assumed that any such force as that computed for $x = r$, about 3.65 kilograms, actually exists between any two atoms. Neither does it seem probable that atoms can get so close that their centers are separated by only a single atomic radius. However, the calculations appear to prove that the electric forces between any atomic models of the kind here assumed would be more than sufficient to prevent collapse through the interaction of their powerful magnetic fields.

7. In 1907 and again in 1908 Weiss[8] reached the conclusion, through a series of magnetic determinations at various temperatures, that the atomic magnetic field of ferro-magnetic substances is of the order 10^7 gauss.

8. At about the same time, that is, in 1908, Ritz[9] gave an elaborate discussion of a molecular model designed to account for the occurrence of series among spectral lines. He recognized the force of Lord Rayleigh's objection to the assumption of a model in which the electrons vibrated under either mechanical (elastic) or electrical forces, since such forces give equations involving squares of the frequencies. He therefore assumed the electrons to vibrate or describe orbits in planes at right angles to the lines of magnetic fields, under which conditions the reciprocal of the wave-length, $1/\lambda$, is given by the equation

$$\frac{1}{\lambda} = \frac{eH}{mv}$$

in which e is the electronic charge, m the electronic mass, H the magnetic field, and v the velocity of light. Hence for this equation to apply to the spectral region of the average Balmer series H must be of the order of 10^8 gauss.

At the distance r from the adjacent pole of a magnet whose pole strength is μ, and length l,

$$H = \mu\left\{\frac{1}{r^2} - \frac{1}{(r+l)^2}\right\}$$

and

$$\frac{1}{\lambda} = \frac{\mu e}{mv}\left\{\frac{1}{r^2} - \frac{1}{(r+l)^2}\right\}.$$

If $l = ns$ and $r = as$

$$\frac{1}{\lambda} = \frac{\mu e}{s^2 mv}\left\{\frac{1}{a^2} - \frac{1}{(a+n)^2}\right\}, \quad n = 1, 2, 3.$$

If $a = 2$

$$\frac{1}{\lambda} = N\left\{\frac{1}{2^2} - \frac{1}{(2+n)^2}\right\}$$

which is identical with Balmer's equation for the hydrogen series.

Hence an electron vibrating at the distance $2s$ from such an elementary magnet of length s and proper strength will give the spectrum line H_α. If 2, 3, etc., of these elementary magnets should be placed end on, the electron would emit H , H_γ, etc., respectively.

Ritz does not state what he considers the probable origin of the elementary magnetic field. As above explained, however, it conceivably may be due to the orbital revolution of the electrons themselves. Further, the different magnetic fields demanded by a Balmer series may, perhaps, be provided by a number of concentric rings of electrons, the field abruptly changing on crossing each ring from one to another interspace. This conception obviates the necessity of assuming the magnets to be placed end on, an arrangement that is impossible if the magnetic fields are of electric origin.

In speaking of Ritz's theory, Zeeman[10] says: "Though there is something artificial about this explanation, it is the best we have at the present moment."

9. Within the past year or two Oxley[11] has shown that the change of magnetic susceptibility on crystallization of some 40 diamagnetic substances examined can be satisfactorily explained on the assumption of molecular magnetic fields of the order of 10^7 gauss. He says in part:

> 1. The change of susceptibility observed on crystallization demands a local molecular field of this order of intensity [10^7 gauss].
>
> 2. The natural double refraction of a crystalline substance as compared with the artificial double refraction which can be induced in a liquid by the strongest magnetic field at our disposal is consistent with the value of the local molecular field implied by (1) for diamagnetic crystalline media.

[8] *Jour. de Phys.*, 6, p. 661, 1907; 7, p. 249, 1908.
[9] *Ann. der Phys.*, 25, 660, 1908.
[10] "Magneto-optics," p. 182, 1913.
[11] *Phil. Trans. Roy. Soc.*, 215, p. 95, 1915.

3. (1) and (2) together imply that the aggregate of the local intensity of magnetization per unit volume of a diamagnetic substance is comparable with the saturation intensity of magnetization of a ferro-magnetic substance.

4. The above results lead to a correct estimate of the energy (potential) associated with the crystalline structure, in virtue of the molecular grouping, as tested by the magnitude of the latent heat.

5. Lastly, unless the forces binding the diamagnetic molecules together were of the order of magnitude stated, we should not be able to detect a departure of the experimental value of the specific heat near the fusion point from the value calculated on Debye's[12] theory [of specific heat]. Every substance investigated by Nernst and Lindemann discloses such a departure.

The above evidence is sufficient to establish the existence of an intense local molecular field of the order 10^7 gauss, if interpreted magnetically, in those diamagnetic crystalline substances (about 40 of which have been investigated) which show a measurable change of χ [specific magnetic susceptibility] on crystallization.

10. Finally, Professor Ernest Merritt, in an address to the American Physical Society in 1915, showed, through the fluorescence bands of uranium salts, interesting evidence of the existence of atomic magnetic fields of the order 10^8 gauss.

Hence, from all the foregoing, which could be greatly elaborated, it seems that there is much and varied evidence in favor of the assumption that atoms have very powerful magnetic fields, due, presumably, to orbital revolutions of electrons.

Of course no one claims that more than a mere beginning has been made in the solution of the problem of the atom, but there is abundant evidence from many sources that this beginning is real.

W. J. HUMPHREYS
U. S. WEATHER BUREAU,
WASHINGTON, D. C.

KENTUCKY AS AN OIL STATE

AT the present writing (June, 1917) Kentucky stands in the limelight as a prospective oil state. Due to the fact that the Irvine District of Estill County has been extended over a large area together with the greatly renewed activity in the older Kentucky fields, operators are now turning their attention to the state as a whole. This is particularly true of oil men from the Mid-continent Field. So it appears that the latter part of this year and the early months of 1918 will forever settle the question as to the state's potential rank in the production of petroleum and natural gas. Test wells are to be drilled in nearly every county in the state and the most modern applications of petroleum geology are being freely used. Up to the present time most of the "wild cat" work has progressed only to the mapping or leasing state, but the high standing of the companies interested is a good indicator of the developments that undoubtedly will follow.

There are four important geological factors that are always met in the search for new oil fields. When all of them are found to work in harmony great fields, like those of Oklahoma, Kansas and Texas or those of Pennsylvania, Ohio and West Virginia, are the result. Geological "structure," such as anticlines, domes, etc., constitute only one of these factors. A large number of structures do not produce oil or gas. They may or may not produce salt water. Furthermore, they may lie in what would be considered favorable regions. In such cases the detail which may have been expended in mapping them is of no avail. Such conditions result from failure of one or more of the three other factors, namely either (1) there is no open "sand" or other porous medium under the structure to serve as a retainer for oil and gas; or (2) there has never been present any salt water or other water in the sand to serve as a concentrating factor; that is, no gathering of oil and gas from a disseminated state to a commercial body; or (3) there is an absence of petroliferous shale or other fossil-bearing rocks that produce oil in a disseminated form.

Now the future of Kentucky as an oil state depends on the four factors above mentioned: (1) structure, (2) sand, (3) water, (4) original oil. There can be no question about the state

[12] *Ann. der Phys.*, 39, 789, 1912.

having three of the above points in its favor, namely, (1) structure, (2) water, (3) original oil. There are numerous favorable structural conditions in various counties of the state. The rocks contain plenty of water and there are some good beds of oil-bearing shale. The Devonian Black Shale is particularly a splendid carrier of original oil. The fourth factor is, however, as yet to be proved of sufficient importance to place Kentucky in high rank as an oil state; namely, "sand." In great oil fields there are large bodies of sand or retaining reservoirs in close proximity to beds of oil-bearing shale. There are frequently several such "sands" in the geological column in close relationships to oil-shale beds.

In Kentucky the "sands" or "porous beds" near the Devonian Oil Shale are carrying most of the oil so far discovered. In Wayne County these sands lie in the Waverly series above the Black Shale, but in other districts the oil is held below the shale in porous beds of limestone. This is true of the oil fields at Irvine, Cannel City, Campton, Menefee County and other districts of eastern Kentucky. In the coal basins of eastern Kentucky and western Kentucky there are a large number of beds of porous quartz sandstone; they lie in the Chester and Pennsylvania series, but in connection with these sandstone beds, oil shales must be proved to exist in order that any particular structure may be found productive. If, for instance, a bed of oil shale like the Devonian Black Shale could be found just above or below the Big Clifty Sandstone at the base of the Chester, then an anticline containing these beds at sufficient depth would most certainly make a big oil and gas field like those of Oklahoma; but it so happens that in a great many cases in Kentucky the oil shales do not lie near dependable porous reservoir rocks or else the porous sandstones in the higher portion of the geological column, such as those above enumerated, do not have near them any great amount of typical oil shale.

In conclusion the writer desires to state it as his opinion that Kentucky is not to rank high as an oil state in comparison with many other areas in the United States where the four factors work in harmony and there are numerous porous sands near beds of oil shale; however, the writer wishes to emphasize the probability that a number of structures in Kentucky will find the four factors working together and will furnish new oil pools that will be highly valuable to those who are fortunate enough to discover them.

Careful studies by geologists working in the state will serve to gather a great deal of important information in addition to merely mapping suitable structural conditions in any particular locality.

James H. Gardner

Tulsa, Okla.

OVERWINTERING OF THE APPLE-SCAB FUNGUS

Though it is generally known that the scab disease of the apple, caused by the fungus *Venturia inequalis,* sometimes attacks the young twigs of susceptible varieties of the apple, yet not much has been published on this phase of the disease in North America.

Morse and Darrows[1] show that the conidia of this fungus survived the winter on apple twigs and germinated readily in the spring. They found no evidence, however, that the mycelium exists during the winter as a living stroma and produces conidia in the spring.

A review of the literature of this subject is given by Morse and Darrows. Wallace[2] also reviews the literature of the persistence of the stroma on the twigs and the hibernation of conidia and is convinced that twig infection is not of common occurrence and that conidia can not withstand winter temperatures.

The writer's attention was first called to scab disease on the young shoots of the apple in the fall of 1915, when a number of badly diseased twigs of a McIntosh apple tree were sent to the college for determination. They were forwarded by Dr. E. W. Henderson, of Mansonville, in this province. The twigs were defoliated for several inches from the tips, and the leaves that remained below showed a very severe attack of scab. The twigs were severely

1 *Phytopath.,* 3: 265, October, 1913.

2 *Bull. Cornell,* 335, 193.

injured, many of them being in a dying condition. The bark was studded with the pustules of the scab disease and abundant conidia were present. Another collection was sent by Dr. Henderson on request a few weeks later. Many of the twigs were now dead and few conidia remained.

Another collection of diseased twigs was received about the first of April from Professor Shaw, collected at Truro Agricultural College, N. S., also from a McIntosh tree. Many of these twigs were killed back several inches and in the dead and also in the living bark abundant pustules of the scab were present. The affected twigs showed the characteristics described by Morse and Darrows. The bark was more or less thickly studded with light brown spots which examination showed to be blister-like areas due to the death and pushing out of the epidermis of the twigs. Many of these light-brown areas were roundish or oval with a dark center. A number, however, lacked the dark central area. Pieces of the diseased bark were removed, embedded in paraffin and sectioned, and the sections and diseased twigs examined. A well-developed stroma was present, and many conidia beneath the raised epidermis. The dark center was composed chiefly of the conidiophores of the fungus, the exposed conidia having fallen away.

Dr. Henderson and Professor Shaw were asked to forward diseased twigs collected about blossoming time, and both generously responded. The collection from Professor Shaw was received about the first of June. A few inches of the tips of some of these twigs were dead, but the bark of the living parts and of the living twigs contained many scattered postules of the apple scab actively producing conidia, the pustules being olive green from the abundant conidia. The dead parts of the twigs were thickly covered with scab pustules of the previous season, but the stroma was dead or not producing conidia.

The fresh conidia were placed in hanging drops of distillated water and they germinated as freely and vigorously as conidia obtained a short time later from the young leaves of an apple in the orchard.

Pieces of the bark containing living pustules were fixed, embedded in paraffin and sectioned. The stroma was very well developed, reaching a maximum thickness of 200 microns, while the maximum thickness of the stroma on the fruit was about 55 microns. It was also evident that the stroma was actively producing conidia at the time of fixation.

Mr. A. G. Turney[3] describes the scab as being troublesome in the twigs of susceptible varieties and states that in one orchard all the twigs of the previous year's growth of the Fameuse were covered with scab spots. He also found the amount of scab on the fruit was much reduced by trimming off the diseased twigs early in the spring. He had previously failed to control scab in this orchard by spraying alone. However, he does not claim the results were entirely due to the spraying. He states in a letter to the writer that the scab is quite common in the coastal regions as a twig infestation, and it may be found also in almost any orchard inland, but rarely so bad as to be a serious hindrance to growth.

Professor Shaw in a letter to the writer states that he found severe twig injury from scab in several different regions in Nova Scotia. The twigs collected at Mansonville, Quebec, at blossoming time by Dr. Henderson did not show any living pustules, but as not many of them had been cut back into the living wood the negative evidence was not satisfactory.

The twigs that had been received from Truro, N. S., about the first of April were left about eight weeks in the laboratory under ordinary conditions. Conidia were then taken from the scabbed areas and were tested in hanging drops of distilled water for germination. A small percentage was found to germinate. A second test gave the same result. The spores were taken from beneath the blistered bark, so that they had a certain amount of protection from the cold and from drying.

The writer is convinced from these experiments and observations that in certain regions

[3] Report of the Horticulturist, Province of New Brunswick, p. 100, 1915.

near the coast apple scab may winter on the twigs of susceptible varieties such as Fameuse and McIntosh as a dormant stroma and produce abundant conidia in the spring. It also confirms Morse and Darrow's conclusion that under certain conditions and with certain varieties of apples diseased twigs and water sprouts may be an important factor in the propagation and spread of the disease.

Mr. J. S. Dash when a senior student at Macdonald College devoted some time to the study of apple scab and the results of his studies were embodied in an unpublished paper now in the college library. He collected scabby apples early in the spring that had lain under the snow all winter and found that about five to ten per cent. of the conidia germinated.

On November 27 of the present year the writer collected scabby apples that had lain under the trees after their fall without protection of any kind. During late fall and early winter the temperature fell below the freezing point fifteen times, rising above during the day. There were two periods of severe frost followed by mild weather, the minimum temperature of the first being 11° F. and of the second on November 26 being 1° F. Conidia were abundant on the scab spots and these were placed in hanging drops of distilled water. The spores germinated freely and vigorously and in twenty-four hours showed many germ tubes over 100 microns in length. By count of the spores present in a number of microscopic fields in several hanging drops it was found that over 26 per cent. had germinated. Only those with well-developed germ tubes were counted. The conidia were examined immediately after being placed in the distilled water, and there could be no doubt whatever that the germ tubes had developed while in the water.

It would seem from these observations that the conidia are more resistant to low temperatures than is generally supposed. As material is available it is hoped to carry on further experiments along this line during the winter and spring.

W. P. Fraser

Macdonald College,
Quebec

SCIENTIFIC EVENTS

BARON DAIROKU KIKUCHI

Baron Dairoku Kikuchi died suddenly at his villa at Chigasaki, Japan, on August 19. Baron Kikuchi was graduated from the University of Cambridge, England, with the rank of "wrangler." He became professor of mathematics in the Imperial University at Tokyo and later its president. He was for a time the Imperial Minister of Education and a member of the Emperor's Privy Council at the time of his death.

He was active and influential in the organization of the Japanese National Academy of Sciences, the National Educational Association and in the development of all the scientific and educational interests of the empire. He was the author of many contributions to scientific journals and several books, including a notable volume on "Japanese Education," consisting of a series of lectures delivered at the University of London in 1907. Baron Kikuchi made several visits to the United States, lecturing in our principal cities and at several of our leading institutions of learning. He was looking forward to another visit to America in the very near future, and his many friends in this country will learn of his death with profound regret.

THE PRODUCTION OF POTASH IN THE UNITED STATES

More potash has been produced during the first six months of 1917 than was made during the entire year 1916. The reports received by the United States Geological Survey, Department of the Interior, have been reduced to terms of the commercial unit commonly used to measure the available or water-soluble potash (K_2O) in the product, and only material actually sold by the producer during this period is included. The weight of the materials handled was therefore much greater than represented by these figures.

This table includes practically all potash produced.

The Nebraska alkali lakes still lead, having yielded about one third the entire production. There are now at least four important operators in this field.

SUMMARY OF THE PRODUCTION OF POTASH IN THE UNITED STATES, JANUARY TO JUNE (INCLUSIVE), 1917

Source	Available Potash (K_2O)	Value at Point of Shipment
Natural salts or brines ...	7,749	$2,808,240
Alunite and dust from cement mills and blast furnaces	1,867	746,576
Kelp	2,143	1,348,095
Distillery slop, wool washings and miscellaneous industrial wastes	2,153	876,714
Wood ashes	111[1]	84,414
	14,023	$5,864,039

The production from Searles Lake, Calif., would undoubtedly be materially assisted by passage of the legislation now before the House of Representatives dealing with the leasing of potash-bearing lands. Continued uncertainty as to the status of titles to this property has hampered development of this important deposit.

No production is reported from feldspar or other silicate rocks, but considerable quantities of potash salts and potash-bearing fertilizers were obtained from the dusts in cement mills and blast furnaces.

The production from kelp was about 15 per cent. of the total, as it was in 1916.

Potash from distillery slop and other organic sources made 15 per cent. or more of the total.

The production of potash from wood ashes, including "first sorts," "pearlash" and other grades, is supposed to have been much greater than it was in 1916, but reports from these producers have been much delayed and the figures obtained thus far are probably not representative. The potash made from wood ashes thus far reported amounted to 222 tons, which is assumed to average at least 50 per cent. K_2O. This is perhaps too low, but definite information as to the grade of this material is difficult to obtain.

The prices quoted range from $3.50 to $6 a unit, a unit meaning 1 per cent. of potash (K_2O) in a ton of the material as marketed—that is, a product carrying 25 per cent. K_2O may be sold at $4 a unit, which would be $100 a ton for the material marketed.

[1] Only 25 reports of production from wood ashes have come in, some of the larger producers not having made returns.

The figures given seem to indicate that the production for 1917 will exceed 25,000 tons of potash (K_2O) or two and one half times that made in 1916. This is about 10 per cent. of the average normal yearly consumption of the country before the war, showing the need of further stimulating domestic production of potash.

THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND

THE annual report of the Conservator of the Museum of the Royal College of Surgeons of England, as abstracted in the *British Medical Journal*, contains a review of work done in the museum. Professor Keith states that besides routine investigations carried on by the staff, Dr. Colin Mackenzie had not only continued his inquiries into the anatomy and physiology of Australian mammals, but acting also as a member of the honorary staff at the Military Orthopedic Hospital, Shepherd's Bush, had found it advantageous to combine his work at the hospital with a research, bearing on his cases, in the workrooms of the College. The comparative anatomy of the muscles of the forearm appears to throw much light on their exact significance in man which may prove of value in surgery. The specimens of bone grafts which accompanied Major E. W. Hey Groves's Jacksonian Prize Essay are distinguished in the report as of particular merit. Many preparations of value have been added to the pathological, teratological, and particularly to the anthropological series; the latter include prehistoric human bones unearthed during trenching operations, not only in home drill but also at the front. The four complete skeletons of gorillas, each representing a different stage of growth, collected in the German Cameroons, and generously purchased and presented to the museum by Sir John Bland-Sutton, will provide an opportunity of illustrating various stages in the growth of that anthropoid which, in a structural sense, is man's nearest relation. Among drawings ac-

quired by the museum is a sketch made for John Hunter representing a duck which had partially assumed the plumage of a drake, a subject in which he was greatly interested. Lastly, we may add that the executors of Dr. Robert Roxburgh have presented the original mechanical spray apparatus which Lord Lister employed in the Royal Infirmary, Edinburgh, and exhibited at the Plymouth meeting of the British Medical Association in 1871 during the course of his address in surgery. It had two nozzles attached to independent caoutchouc tubes, furnishing large clouds of spray, that could be directed, if necessary, to opposite sides of the part operated on. Dr Roxburgh was Lister's last house-surgeon at the Royal Infirmary. Lister went to King's College, London, to fill the chair of clinical surgery in succession to Sir William Fergusson in 1877.

THE MAYO FOUNDATION AND THE UNIVERSITY OF MINNESOTA

The board of regents of the University of Minnesota have ratified by unanimous vote the permanent agreement making the Mayo Foundation at Rochester the absolute property of the university, to be used perpetually for higher medical education and research. Securities totaling $1,650,345, representing the fortunes of Drs. William J. and Charles Mayo, were turned over to the university.

"We turn over to the regents the bulk of our savings of a generation as an outright gift," said Dr. William J. Mayo, who is a member of the board of regents, but who did not vote on the proposal. "The money came from the people, and we feel it should return to the people—a continuing fund that shall serve this state for generations to come."

Expenses of the foundation will be paid by the Drs. Mayo until a fund of $2,000,000 has accumulated. Thereafter the income from the fund will maintain it.

The foundation has been affiliated with the university for two years, which was agreed upon as a trial period. Under the final agreement the headquarters of the foundation can be moved from Rochester to another point in the state after twenty-eight years. Ten per cent. of the yearly income may be expended outside the state and another ten per cent. may be used to investigate epidemics inside and outside the state.

It was announced that one of the Mayos would go to France with recruits next year and that they would take turns there until the end of the war.

SCIENTIFIC NOTES AND NEWS

M. Paul Painlevé has been chosen to be premier of the French Republic. M. Painlevé has been professor of mathematics in the University of Paris and of mechanics at the Paris Polytechnic School.

M. G. Fayet, assistant director of the Nice Observatory, has been appointed director in succession to the late General Bassot.

Dr. R. W. Wood, professor of physics in the Johns Hopkins University, is now in France engaged in scientific research in cooperation with members of the Paris Academy of Sciences. Dr. Wood left about three weeks ago, following the receipt of a cablegram from Premier Ribot offering him the tentative ranking of major in the French army.

Dr. Raymond Pearl, biologist and head of the department of biology of the Maine Agricultural Experiment Station, has been granted leave of absence from that institution for the duration of the war, to take charge of the statistical department of the United States Food Administration. He left the experiment station for Washington early in June, accompanied by Dr. Frank M. Surface, biologist of the Maine Station, who was also granted leave of absence for the same work. The following are associated, for the duration of the war, with Dr. Pearl in the statistical work of the Food Administration:

Dr. H. S. Jennings, The Johns Hopkins University.
Dr. W. E. Kellicott, Goucher College.
Dr. H. R. Willard, University of Maine.
Mr. John Rice Miner, Maine Agricultural Experiment Station.

Dr. A. W. Dox, for the past seven years chief of the section of chemistry of the Iowa Agricultural Experiment Station, has been granted leave of absence to accept a commis-

sion as captain in the food division of the Sanitary Corps of the National Army.

DR. FRANK C. GEPHART, chemist of the Russell Sage Institute of Pathology, has received a commission as captain in the Sanitary Corps, United States National Army, with headquarters at the Surgeon General's office, Washington, D. C.

DR. H. R. GLASCOCK has resigned from the professorship of biology at De Pauw University and will engage in service with the Medical Corps.

THE War Department has refused to accept the resignation of Dr. James W. Inches, health officer of Detroit, from the Detroit College of Medicine and Surgery Base Hospital No. 36, in order to allow him to accept an appointment by the American Red Cross as one of the fifteen commissioned specialists to study conditions abroad.

B. K. COGHLAN has resigned as associate professor of highway engineering at the Agricultural and Mechanical College of Texas. He is captain in the Engineer Officers' Reserve Corps and has been ordered to Ft. Leavenworth. E. O. Francisco, who was assistant professor of civil engineering at the college during the last session, has been commissioned a second lieutenant in the Engineer Officers' Reserve Corps and has also been ordered to Ft. Leavenworth.

DR. JAMES D. MADDRILL, of the Travelers Insurance Company, has become actuary of the bureau of efficiency and economy at Washington. Dr. Maddrill has been in charge of the International Geodetic Observatory at Ukiah, Calif., and instructor in insurance mathematics at the University of California. His position at Washington will call for the preparation of a plan for pensioning all the civil employees of the government, numbering more than 300,000, and for other calculations of an actuarial and statistical nature.

DR. LEWIS R. HARRIS has been appointed director of the Bureau of Preventable Diseases of the New York City Health Department to succeed Dr. Bertram Waters, who has resigned from the Department of Health to resume his private practise.

MR. L. E. WARREN, for eight years associate chemist in the chemical laboratory of the American Medical Association, has resigned his position to take charge of the research laboratories of the New York plant of Wm. R. Warner & Co.

DR. MAURICE G. MEHL, former head of the department of geology and director of the school of engineering and geology at the University of Oklahoma, has given up his work in that institution and will for the present give his time to a study of the oil and gas conditions of Oklahoma and Kansas.

PROFESSOR JUNIUS HENDERSON, of the University of Colorado, has recently returned from an expedition to northern Wyoming. The collections obtained consist principally of land shells and fossils.

PROFESSOR C. C. NUTTING has recently returned from Barbados and other West Indian Islands, where he has been looking over the ground in preparation for a party of zoologists who propose to visit that region next spring. This expedition will be under the auspices of the graduate college of the State University of Iowa, and will consist of instructors and graduate students in zoology; and the plan is to select some suitable point as a base of operations for the exploration and study of typical coral reefs. Dredging will be carried on, probably to a depth of two hundred fathoms, and a zoological laboratory will be established on shore. In his preliminary trip Professor Nutting visited the Islands of St. Thomas, St. Croix, St. Kitts, Antigua, Dominica, Martinique, St. Lucia and Barbados. The proposed expedition will probably make either Barbados or Antigua the base for their operations.

THE Norwegian explorer, Roald Amundsen, is at present preparing an Arctic expedition, which will start next March or April. A new expedition ship has been built, replete with every modern requirement in the way of technical equipment. Amundsen intends to take an aeroplane on board to be used for reconnoitering in the Arctic regions.

Lecturers before the graduate summer quarter in medicine of the University of Illinois included Dr. Sidney I. Kornhauser, assistant professor of zoology in the Northwestern University, on "Sex determination and the nature of secondary sexual characteristics"; Dr. Reuben M. Strong, associate professor of anatomy in the Vanderbilt University, on "Adaptation in bone architecture"; Dr. Orville H. Brown, of Phœnix, Arizona, on "Asthma," and Dr. Addison Gulick, assistant professor of physiology in the University of Missouri, on "Over-feeding and the calorie problem in human metabolism."

We learn from *Nature* that the fifth annual meeting of the Indian Science Congress will be held in Lahore on January 9 to 12 next, under the presidency of Dr. G. T. Walker, F.R.S., Director-General of Observatories. The sectional presidents will be: Dr. L. Coleman (Agriculture), Dr. Wali Mahomed (Physics and Mathematics), Dr. G. J. Fowler (Chemistry), Dr. Choudhuri (Zoology and Ethnology), Mr. R. S. Hole (Botany), Mr. E. S. Pinfold (Geology). Dr. J. L. Simonsen, of the Presidency College, Madras, is the honorary secretary for the meeting.

Second Lieut. Edward Osler, R.A., only son of Sir William Osler, died in England on August 31. He was wounded recently while on active duty in France, and had been taken to England for treatment.

Professor S. B. Kelleher, Erasmus Smith professor of mathematics in the University of Dublin, died on August 18.

It is reported from London that A. Chester Beatty, a Columbia alumnus, has offered his London house as an American Officers' Hospital under the supervision of the Columbia Hospital Unit. The Columbia Unit is under the direction of Dr. George E. Brewer, of the College of Physicians and Surgeons and the Presbyterian Hospital. The unit is now in England. It is also stated that American medical officers will take charge of the military hospitals at Manchester, Salford, Liverpool, Leeds, Birmingham, and Cardiff, and the civil medical practitioners at present in charge of those hospitals will be informed that their services are no longer required. It is understood that the reason for the change is that the services of the civilian doctors are required for the needs of the population, who have been inadequately served, owing to the attendance of so many physicians at the military hospitals.

A Chemical Industries Bureau is in course of formation in Sweden, the object of which will be to bring together the Swedish chemical industrial interests.

The Tootal Broadhurst Lee Company of Great Britain announces that "assured of the importance of research and education in the struggle for the world's trade, the directors have decided to set aside £10,000 a year for five years for this purpose." The provisional committee on research and education for the cotton industry will, at the close of the current holiday season, issue a prospectus of the new government-incepted and aided organization. This definite industrial research federation of the cotton trade will be followed by the establishment of institutes and laboratories. A provisional committee to organize textile research associations in the woollen trade has been formed.

The *Proceedings* of the Nineteenth International Congress of Americanists, held at Washington, December 27–31, 1915, has just made its appearance. It is a handsome royal octavo volume of 717 pages, with many illustrations, and in addition to the proceedings of the congress includes ninety articles on American archeology, ethnology, folklore and tradition, history, linguistics, and physical anthropology. The work was prepared by Dr. A. Hrdlička, of the United States National Museum, who was general secretary of the congress, and edited by Mr. F. W. Hodge, of the Bureau of American Ethnology.

By the will of Julian A. Hellman, a residuary fund, which may amount to $100,000, is created to be used by Mount Sinai Hospital for the purpose of cancer research work.

FREE public lectures of the New York Botanical Garden are being delivered in the Lecture Hall of the Museum Building of the Garden, Bronx Park, on Saturday afternoons, at four o'clock, as follows:

September 1. "Collecting fungi in the Catskills," by Dr. W. A. Murrill.

September 8. "The origin and history of soils," by Dr. A. Hollick.

September 15. "Growing fresh vegetables in the back yard," by Mr. H. G. Parsons.

September 22. "Some botanical features of northern Cape Breton," by Dr. G. E. Nichols.

(Exhibition of Dahlias, September 22 and 23)

September 29. "Growing nut trees," by Dr. W. C. Deming.

October 6. "Autumn coloration," by Dr. A. B. Stout.

October 13. "The relation of forests to water supply," by Dr. G. C. Fisher.

(Catskill Aqueduct Celebration Lecture)

October 20. "Fall planting and winter protection," by Mr. G. V. Nash.

THE Paris Academy of Sciences has decided to establish a National Physical and Mechanical Laboratory for the purpose of scientific research, directed in a marked degree to the benefit and use of the industries. The laboratory will be controlled by a council, of which half the members will be nominated by the academy, one fourth by the state department, and the remainder by the chief industrial associations. The executive control will be in the hands of a small technical committee. Existing laboratories engaged in similar work will be affiliated with the National Laboratory, and will work in close relationship with it. Substantial funds are to be provided for working expenses and for the assistance of the affiliated institutions.

AT the request of the government, the council of the British Medical Association has submitted the following plan for the creation of the Ministry of Health: "That a ministry of health should be created to take over from existing government departments such duties as are concerned with the health of the community, and to deal with those duties only; that the administrative functions of the ministry should be carried out by a board presided over by a minister of cabinet rank; that the country be divided into suitable administrative areas under local administrative health centers consisting of representatives (*a*) of the rating authorities; (*b*) of the education authorities; (*c*) of the persons contributing to a scheme of health insurance (including employers of labor); (*d*) the medical profession; (*e*) public hospitals; (*f*) dentists; (*g*) pharmacists, and (*h*) nurses; that the principal medical officers of each center should be two, of equal status, one representing the clinical side (chief clinical officer) and the other the preventive side of medicine (medical officer of health); that for each area, hospitals, clinics or treatment centers should be recognized or established at which persons entitled to treatment under the public scheme should be able to obtain institutional, consultative or specialist services on the recommendation of their medical attendant." The meeting passed a resolution by an overwhelming majority in favor of the appointment of a ministry of health.

UNIVERSITY AND EDUCATIONAL NEWS

BROWN UNIVERSITY receives $100,000 for a teachers' fund and $4,000 for the purchase of volumes of American poetry by the will of the late Samuel C. Eastman, of Concord, N. H. The Concord Public Library is given $2,000, the New Hampshire Historical Society $4,000, and $3,000 will go to charity. One half the residue of the estate is willed to Brown University, one fourth to the Concord Public Library, and one fourth to the New Hampshire Historical Society.

THE University of Maine and Bates and Colby Colleges have postponed their opening for about a month to allow students to continue their work on farms and in industries.

PROFESSOR WILLIAM A. SCHAPER, of the department of political science of the University of Minnesota, has been dismissed, following an investigation of the attitude on the war of

members of the faculty. Professor Schaper denies that he has been disloyal.

Dr. William Allen Neilson, professor of English at Harvard University, has been elected president of Smith College. He succeeds Dr. Marion L. Burton, who has become president of the University of Minnesota.

James C. Nagle has been appointed dean of engineering and professor of civil engineering in the Agricultural and Mechanical College of Texas, succeeding D. W. Spence whose death occurred in June.

Professor W. S. Franklin, formerly of Lehigh University, has accepted a position as special lecturer and teacher at the Massachusetts Institute of Technology, partly in the department of physics and partly in the department of electrical engineering. Professor Franklin requests his correspondents to note his new address.

Dr. C. H. Shattuck, for the past eight years head of the department of forestry, University of Idaho, has accepted the position as professor of forestry with the University of California.

Dr. Wright A. Gardner, formerly associate professor of plant physiology in the University of Idaho, has been appointed professor of plant physiology and head of the department of botany in the Alabama Polytechnic Institute.

Dr. Alfred H. W. Povah, formerly instructor in botany in the University of Michigan, has been appointed special lecturer in forest mycology in The New York State College of Forestry at Syracuse University.

Mr. Ralph Hubbard, formerly of Cornell University, has been appointed assistant in the museum and zoological department of the University of Colorado.

Mr. Samuel Wood Geiser, formerly professor of biology and geology in Guilford College, has been appointed professor of biology in Upper Iowa University.

At the University of Oregon, Charles H. Edmondson, Ph.D. (Iowa, '06), assistant professor of zoology, and Albert E. Caswell, Ph.D., (Stanford, '11), assistant professor of physics, have been promoted to full professorships, and Raymond H. Wheeler, Ph.D. (Clark, '15), instructor in psychology, has been made an assistant professor. During the present summer Dr. Edmondson has been studying the clams of the North Pacific Coast with a view to their conservation for food purposes.

Dr. Lloyd Balderston, of Ridgway, Pa., has been appointed professor of leather chemistry and technology in the college of agriculture of the Tohoku Imperial University, at Sapporo, Japan.

DISCUSSION AND CORRESPONDENCE

ON THE "RAWNESS" OF SUBSOILS

In the interest of accuracy the writer feels impelled to call the attention of investigators of soils to some facts with reference to the infertility of subsoils which do not seem to be generally appreciated. This statement is called forth at this time by the recent paper of Alway, McDole and Rost[1]; the observations upon which it is based are of long standing but have not been described because of matters of greater importance which have intervened to prevent such description. The authors just cited call attention to the characteristic sterility of subsoils of humid regions with which every student of soils is of course familiar. No one can deny that fact. They go on, however, to cite Hilgard, and Wohltmann who had visited California, to the effect that subsoils of arid regions are not sterile, but serve just as well or better than surface soils in that region for the support of plant life whether the latter be of legume or non-legume order.

Neither Hilgard's nor Wohltmann's observations are in full accord with mine except in certain cases which I shall refer to below. In studying the soil conditions of the Great Valley of California and particularly those of the citrus and alfalfa growing districts, I have repeatedly observed the vegetation, natural or planted, which is to be found on the freshly graded fields. Grading is done, of

[1] *Soil Science*, Vol. 3, p. 9, January, 1917.

course, in preparation of soils for irrigation and may result frequently in the removal of several inches to two, three or even more feet of surface soil in order that a level field may be produced. This is particularly striking in the case of the well-known and, on genetic grounds, highly interesting "hog wallow" lands which comprise very large areas of the Sacramento and San Joaquin Valleys. On the citrus lands either barley or alfalfa may be grown for a year or more in the preparation of the soil for the citrus trees. Wherever barley is sown, it is always possible to distinguish between the spots in the field from which the surface soil has been removed and those which still consist of surface soil. On the latter the barley looks as nearly normal as the given soil type will permit it, whereas on the former the barley growth, if it is at all visible, is stunted and yellow and frequently does not live though the growing season. Only in places where considerable surface soil has in the process of grading become admixed with the subsoil, have I ever noted an approach to good barley growth.

In the case of alfalfa, however, I can only recall one or two instances of failure to grow as well on the raw subsoil as on the surface soil. The difference between the behavior of barley and alfalfa on the subsoil in question is probably to be ascribed to the paucity in *available nitrogen* which is known to characterize subsoils. Under such conditions, barley can, at best, only make very poor growth, whereas the alfalfa, if inoculated, is independent of the available nitrogen supply in the soil. It should be added that with the admixture to some extent of surface soil with the subsoil in the process of grading a large enough number of *B. radicicola* is introduced all through the graded land to insure to alfalfa the necessary nitrogen for its growth, an advantage which that legume in common with others does not share with non-legumes. The case noted in Berkeley by Hilgard regarding which the latter is quoted by Alway, McDole and Rost, is undoubtedly that of an observation on the campus of the University of California, on the surface of which there has been so much filling and cutting for a number of years as to render questionable in any instance the real origin of the soil or subsoil observed. In my knowledge of the campus, I have known the excavation of subsoil material which had not long before been surface soil to result in bringing it back to its original condition again. We should not expect such material to be as inert and as unresponsive in growing non-legumes as real subsoil material. Arguing, however, from direct observation, I should like to add that I have frequently observed on the same campus, in places in which deep excavations were accomplished, that very little vegetation appeared for a year or more after the true subsoil material had been opened to air, light and the sun's warmth, as well as to the effects of inoculation by dust from surface soils. Such vegetation as did establish itself consisted almost invariably of bur clover. *Medicago denticulata.* When other plants were present, they were usually found to be alfilaria, *Erodium cicutarium,* a plant which is most commonly associated with bur clover on California soils and which probably profits by the nitrogen fixed by the clover. The bur clover plants found on such sterile subsoil material as is above described have always been found to be abundantly supplied with nodules.

The writer's observations lead him to believe, therefore, that subsoils of arid regions are nearly if not quite as raw as those of humid regions and that despite the great differences between the two in many respects, the first will not support plant growth to a much greater extent than the latter. The close resemblance which obtains between our subsoils and our surface soils, and which does not characterize the soils and subsoils of humid regions, appears, therefore, to be no index to the productivity of our subsoils. I should judge, in fact, from the statements of Alway, McDole and Rost, that the California subsoils are not superior to the Nebraska subsoils in any respect from the point of view here under consideration. As above pointed out, it seems fairly certain that the chief cause of the rawness of subsoils is the lack of available nitrogen in them for the support of the non-legume.

This deduction seems to be supported by the fact that legumes when inoculated will grow in the raw subsoils, whereas the non-legumes will not. That legumes will not grow on subsoils of humid regions as is claimed by Alway, McDole and Rost is not, so far as I am aware, proved. In any case their claim that the failure of such inoculated legumes to develop on humid subsoils "is to be attributed to a lack of availability of the phosphoric acid or of the potash or of both," appears to be an assumption which is unsupported by fact. Data on the content of water-soluble phosphoric acid and potash in subsoils of humid regions give no indication, so far as the writer is aware, of a paucity in those respects which would at all account for the total failure to develop manifested by the inoculated legume plants mentioned above. If inoculated legume seeds do fail to develop on humid subsoils, such failure must be accounted for, it would seem, on other grounds than those proposed by Alway, McDole and Rost.

It may also be added here that Hilgard's explanation for the "rawness" of subsoils is probably neither correct nor necessary. One is not obliged to assume a washing down of fine clay and silt particles from the soil into the subsoil to account for very imperfect aeration in the latter. Indeed, the sands of nearly uniform texture for several feet in depth, which are common in California, exhibit similar rawness in the subsoil, to that of the loams and clays which are underlaid by almost impenetrable silty clays.

SUMMARY

1. Subsoils of arid regions are certainly no less "raw" than those of semi-arid regions, and probably only slightly less so than those of humid regions.

2. If, as seems as yet unproved, inoculated legume seeds fail to develop on humid subsoil material, such failure can not justifiably be attributed as is done by Alway, McDole and Rost, to a lack of available phosphoric acid and potash.

3. A lack of available nitrogen probably is sufficient to account for rawness of subsoils.

4. The poor aeration of subsoils which indirectly results in their rawness, may be accounted for more simply than by Hilgard's explanation of the washing down of fine particles into the subsoil, which prevents proper aeration.

Chas. B. Lipman
University of California

NORTHERN LIGHTS

To the Editor of Science: Readers of Science will be interested to note the following observation of the northern lights. We noted them here on the evening of August 9 at about 8:45. They extended across the sky from northwest to east by northeast. They appeared as streaks, not very wide, and there was little or no flickering. A diffuse glow in the sky was more evident than the streaks. The night was clear and bright, so that this may account for the fact that they were not very prominent. They seemed to extend from 40° to 70° in height. At 9:35 P.M. they were still visible, but shortly after 10 there was no trace of them.

The northern lights, of which so many accounts were published in Science about this time last year, were observed here also, although I do not recall that any one reported the fact.

Thomas Byrd Magath
U. S. Bureau of Fisheries
Biological Station,
Fairport, Iowa

THE NEW MOON

To the Editor of Science: In making some computations last March about the occurrence of New Moon, an error of statement was discovered in the 9th edition of the Encyclopædia Britannica under "Calendar," Vol. IV., p. 594, and repeated in the 11th edition, Vol. IV., p. 993; it is also given in Barlow & Bryan's "Mathematical Astronomy," p. 215. The erroneous statement is that New Moon occurred on January 1 in 1 B.C. New Moon in January, 1 B.C., occurred on January 25, 12^h 26^m Jerusalem Mean Civil Time.

Otto Klotz
Dominion Observatory,
July 31, 1917

ERASMUS DARWIN AND BENJAMIN FRANKLIN

EXTRACTS from two previously unpublished letters from Erasmus Darwin to Benjamin Franklin appeared in SCIENCE, June 2, 1916. Concerning one of these letters, Dr. L. Hussakof, the author of the article in which they appeared, wrote:

> It is addressed simply: "Dr. Franklin, America," and opens in the grandiloquent style of the time (1787) as follows:
>
> "*Dear Sir,* Whilst I am writing to a Philosopher & a Friend, I can scarcely forget that I am also writing to the greatest Statesman of the present, or perhaps of any century. . . ."

The following paragraph from Anna Seward's "Memoirs of the Life of Dr. Darwin," which appeared in 1804, throws an interesting sidelight on this letter:

> In allusion to (his) perpetual travelling, a gentleman once humorously directed a letter, "Dr. Darwin, upon the road." When himself wrote to Dr. Franklin, complimenting him on having united philosophy to modern science, he directed his letter merely thus, "Dr. Franklin, America"; and said he felt inclined to make a still more flattering superscription. "Dr. Franklin, the World." His letter reached the sage, who first disarmed the lightning of its fatal power, for the answer to it arrived, and was shown in the Darwinian circles; in which had been questioned the likelihood of Dr. Franklin ever receiving a letter of such general superscription as the whole western empire. Its safe arrival was amongst the triumphs of genius combined with exertion, "they make the world their country."

The other hitherto unpublished letter Dr. Hussakof says is "remarkable chiefly for one sentence near the end, which contains the amazing information that even as far back as that (1772), someone was puzzling over the idea of making a phonograph. 'I have heard,' writes Dr. Darwin, 'of somebody that attempted to make a speaking machine, pray was there any Truth in any such Reports?'"

Charles Darwin in Krause's "Life of Erasmus Darwin" (p. 120), says that a speaking machine was a favorite idea of his grandfather and for this end he invented a phonetic alphabet. Erasmus Darwin himself says in his "Temple of Nature" (1802), note No. 15:

> I have treated with greater confidence on the formation of articulate sounds, as I many years ago gave considerable attention to this subject for the purpose of improving shorthand; at that time I contrived a wooden mouth with lips of soft leather, and with a valve over the back part of it for nostrils, both which could be quickly opened or closed by the pressure of the fingers, the vocality was given by a silk ribbon about an inch long and a quarter of an inch wide stretched between two bits of smooth wood a little hollowed; so that when a gentle current of air from bellows was blown on the edge of the ribbon, it gave an agreeable tone, as it vibrated between the wooden sides, much like a human voice. This head pronounced the *p*, *b*, *m*, and the vowel *a*, with so great nicety as to deceive all who heard it unseen, when it pronounced mama, papa, map and pam; and had a most plaintive tone, when the lips were gradually closed.

All the other scientific subjects referred to by Darwin in these letters to Franklin are to be found discussed in one or more of Darwin's published works.

Dr. Darwin's prophetic insight along biological lines is well paralleled in another sphere in the following verses from his "Economy of Vegetation," Canto I.:

> Soon shall thy arm, UNCONQUER'D STEAM! afar
> Drag the slow barge, or drive the rapid car;
> Or on wide-waving wings expanded bear
> The flying-chariot through the fields of air.

And again in a footnote:

> There is reason to believe it (steam) may in time be applied to the rowing of barges, and the moving of carriages along the road. As the specific levity of air is too great for the support of great burdens by balloons, there seems no probable method of flying conveniently but by the power of steam, or some other explosive material, which another half century may probably discover.

Finally, the following lines from the "Economy of Vegetation," Canto II., may have added interest to-day:

> So, borne on sounding pinions to the WEST,
> When Tyrant-Power had built his eagle nest;
> While from his eyry shriek'd the famish'd brood,
> Clenched their sharp claws, and champ'd their beaks for blood,
> Immortal FRANKLIN watch'd the callow crew,
> And stabb'd the struggling Vampires, ere they flew.

—The patriot-flame with quick contagion ran,
Hill lighted hill, and man electrified man;
Her heroes slain awhile Columbia mourn'd,
And crown'd with laurels Liberty return'd.

Lorande Loss Woodruff
Osborn Zoological Laboratory,
Yale University

SCIENTIFIC BOOKS

The Modern Milk Problem. By J. Scott MacNutt, Lecturer on Public Health Service, Massachusetts Institute of Technology. Macmillan Co., New York. 253 pages. Price $2.00

It would seem as if little that is new and interesting could be added to the multitudinous papers, circulars and books on milk that have appeared in recent years. The present book is a distinct acquisition, however, to the literature on the subject. It is written in a clear style, and presented in such a way as to command the reader's attention throughout. While the various important phases of milk production are dealt with at some length, with due emphasis on the necessity of producing clean and safe milk, its most distinctive feature is its illuminating treatment of the economic factors which enter into the present-day milk problem.

Like Rosenau, the author believes that the producer is the victim of unfortunate circumstances, that he is little understood, and that as a rule he does not receive sufficient compensation for the capital which he has invested, the risks which he assumes, and the efforts and long hours which he devotes to his work. On the other hand, milk is milk to the consumer, and he will, with some exceptions of course, not protect himself against possible infection, but relies upon health authorities and medical or civic organizations to stand vigil for him.

One of the chief obstacles to a satisfactory solution of the milk problem is the lack of understanding and cooperation between the producer and those who are entrusted with the enactment and the enforcement of rules and regulations to protect the public. The State Agricultural Experiment Station is to-day doing much to instruct the farmer in the ways of economic milk production, a duty which no other agency can better perform.

Good and pure milk is a necessity. Aside from an inconsiderable amount of certified milk, milk is either good or bad, according to the author. So long as the ordinary producer stays within the minimum requirements of the law he has no incentive to increase the quality of his products. A premium paid on quality is one of the solutions of the good milk problem. Few producers are paid for the extra effort, and hence are content if they remain unmolested by the prosecutor.

The laboratory method of determining the quality of milk is, in the author's judgment, the most important, while inspection is of little merit, aside from the instruction to the producer in rational methods of clean milk production. The dairy score card also is of relatively little value, as it does not furnish a true index of the real quality of milk. Pasteurization, except for the highest grade, is necessary to protect the consumer. Grading and the laboratory examination are the most important single means of sanitary control, grading being the most important single factor in economic adjustment. Fair milk prices should be paid to both farmer and dealer on the basis of quality.

Several pages of well-chosen references are given, and the last 68 pages of the book are devoted to a comprehensive appendix in which valuable technical and statistical information is contained, as shown in the titles: Milk Statistics in the United States, Grading Systems of the Commission on Milk Standards, the North System, Costs and Prices, and Local Experiences and Investigations.

The book is designed to furnish information, in the author's words—"not merely for health officials and milk inspectors, but also for dairymen and city milk dealers, agricultural authorities, legislators charged with the framing of milk laws, inquiring consumers and members of organizations engaged in efforts to secure better milk supplies, physicians, and all others who are interested in the

understanding and solution of the milk problem."

LEO F. RETTGER
SHEFFIELD SCIENTIFIC SCHOOL,
YALE UNIVERSITY

SPECIAL ARTICLES

GRAVITATIONAL REPULSION[1]

IN a paper entitled "Gravitation and Electrical Action" published by The Academy of Science of St. Louis, on July 28, 1916,[2] the following passage may be found:

> These results seem to indicate clearly that gravitational attraction between masses of matter depends upon their electrical potential due to electrical charges upon them.

Every working day of the present college year has been devoted to testing the validity of the above statement. All of the experimental results confirm this conclusion. No discordant results have been obtained. Not only was gravitational attraction diminished by charges of electricity upon the attracting bodies, when direct electrical action was wholly cut off by a metal shield, but gravitational attraction was converted into a repulsion which was greater than the normal attraction. On two days, when the influence machine, driven by a single-phase motor, was most highly efficient, the value of the gravitation constant was reduced by 250 and 300 per cent. of its maximum value. The maximum value of the gravitational attraction was evidently exerted when the potential of the attracting masses was zero absolute. The suspended masses were two spheres of lead, having a diameter of one inch, and distant from each other 91.5 cm. They were suspended on two untwisted threads of silk fibers, about 3.4 millimeters apart, and having a length of 179 cm. These silk threads were tied together at the top and hung around a pulley one inch in diameter. Below were two movable pulleys by means of which the distance between the silk threads could be adjusted to a parallel position. The large masses were spheres of lead having a diameter of 10 inches. They were mounted on blocks of wood having caster-wheels provided with roller bearings, which rested upon heavy sheets of hard rubber. The screen around the suspended masses was in part composed of wood, forming the top, bottom, and ends. The sides which faced the large masses each consisted of two sheets of heavy cardboard, outside of which was a sheet of metal. They were securely clamped to the top, bottom and ends of the enclosing shield by means of bars of wood and the joints were sealed by means of bees-wax, which was melted and run into the joints by means of a hot iron. The entire screen was then surrounded by another shield of metal. A layer of air about 1.5 cm. in thickness was thus formed between the two metal sheets on either side. A sheet of glass was also placed between each of the large masses and the metal sides of the shield. A box of metal filled with loose cotton-batting was placed in contact with the metal shield, alternating in position with the large masses. This was done in order to prevent as far as possible radiation from the northern sky from producing unbalanced convection currents in the air within the screen.

The large masses, the metal boxes containthe cotton, and the metal screen were all in metallic connection with each other. All heat from the heating system of the building was cut off. The change in the position of the suspended masses was determined by means of a mirror, telescope and scale, observation being made through a narrow slit in the screen which was covered by a plate of photographic glass, sealed to the inner sheet of metal.

Three feet distant from the ends of the screen and the side opposite to the observing telescope was a line of insulated metal rods upon which was hung metal strips armed with 800 pins. At one end of this line of rods was a metal disc armed with 150 pins. Facing this disc was a duplicate disc attached to a line of rods hung upon silk cords, and leading to the influence machine in an adjoining room. There was no gap in the line of rods excepting between the two discs having 150 pins soldered to them. The rods carrying the 800 pins were

[1] Abstract of a paper to be published by the Academy of Science of St. Louis.

[2] *Trans. Acad. of Sc. of St. Louis*, XXIII., 4, p. 173.

directly connected with the shield and the large masses if a rapid change was desired.

When either the positive or the negative terminal of the machine was applied, the attraction of the large masses for the suspended masses was diminished. It sometimes happened that a slight increase was shown at first, until a condition of zero potential was reached. This was only observed when direct contact of the masses with the 800 pins was not made. It then required several hours for the decrease in gravitational attraction to reach a limit. Then when the other terminal was applied the masses slowly returned to the original position. If this deflection were due to heat effects causing convection currents of air within the shield, this return motion due to change in terminals would not occur.

On the occasion when the most marked effects were obtained, the decreasing effect took place very slowly, requiring five hours. There was no direct contact between the large masses and the 800 pins. The positive terminal had been applied. Negative electrons were being drained from the air surroundiing the large masses and from the outer surface of these masses. Gravitational attraction had been reduced to zero. The negative terminal was then applied, and the masses were directly connected with the pin conductors by means of a metal rod. In five minutes (the time of a semi-vibration) the suspended masses had swayed back about half the angle over which they had slowly moved in the previous five hours. They then swayed back and oscillated to and fro, the mean of the extreme readings representing a decrease of 250 per cent. in the normal value of gravitational attraction between the masses. The arc of vibration during the next forty minutes was about equal to that due to normal attraction between the masses.

On the next morning the suspended masses were at rest, in a position which indicated that the large masses still repelled the suspended masses with a force about 2.5 times that of gravitational attraction. This position remained constant for two hours. The positive terminal was then applied and direct contact was made between the masses and the 800 pin conductors. During the next eighteen minutes the suspended masses swayed over an arc very nearly equal to that due to normal attraction. The attraction between the masses was increased. During the next twelve minutes they swayed backward over an arc about twice as great. The condition of zero potential had been passed. The force steadily decreased during the following ninety minutes. The gravitational attraction had then decreased to more than 300 per cent. of its maximum value. The negative terminal was then applied, and in two hours the reading was that at the beginning of the work of the previous day.

It is not necessary to continue an experiment of this kind throughout an entire day. Either terminal may be applied when the suspended masses are at rest, until an appreciable decrease in the gravitational attraction has become evident. A reversal of contacts of the machine may then be made and the masses will slowly sway back to their original position. This operation requires less than one hour. The evidence is as convincing as that produced by a feeble current of electricity upon a magnet suspended above it.

No attempt has been made in this work to obtain precise results. The aim has been to determine whether it would be proper to construct the much more expensive apparatus which will be needed, and which will permit the independent electrification of the suspended masses. Some results which have been obtained have aroused the suspicion that the "charges" on these masses varies from day to day, and that when their potential due to these charges is zero absolute, the electrification of the large masses will have no effect upon gravitational attraction. A modification of the apparatus used by Boys will be required.

The work here described has been done in a private laboratory in the second story of Ead's Hall, now occupied by the physics department of Washington University.

My thanks are due to the Carnegie Institution of Washington, for financial aid in this work.

Francis E. Nipher

THE CATALASE CONTENT OF LUMINOUS AND NON-LUMINOUS INSECTS COMPARED[1]

ACCORDING to Dubois[2] and others the production of light by luminous organisms is an oxidative process. If this is true then it would seem that oxidation should be correspondingly more intense in luminous insects than in non-luminous insects. It has been shown that the catalase content of the different muscles of animals is proportional to the amount of oxidation in these muscles and that the catalase is increased or decreased under the same conditions under which oxidation is increased or decreased.[3] This and similar evidence would seem to indicate a close relationship between the catalase content of a tissue and the amount of oxidation in that tissue If oxidation is more intense in luminous than in non-luminous insects then the catalase content per unit of weight of luminous insects should be greater than that of non-luminous insects. The object of this investigation was to determine if the catalase content per unit of weight is greater in a luminous insect, such as the firefly (Photinus), than it is in non-luminous insects, such as moths, butterflies, honey-bees and bumble-bees.

Method.—After the insect was weighed it was ground up with sand in a mortar. This ground material was added to 50 c.c. of hydrogen peroxide in a bottle and as the oxygen gas was liberated from the hydrogen peroxide by the catalase it was conducted through a rubber tube into an inverted burette previously filled with water. In this way the amount of oxygen liberated in ten minutes from 50 c.c. of hydrogen peroxide was collected. The volume of oxygen was read off directly from the burette, where it had displaced the water. After this volume had been reduced to standard atmospheric pressure the resulting volume was taken as a measure of the catalase content of the insect. Knowing the weight of the insect, the amount of catalase per 30 milligrammes of material was calculated. The calculation was made on the basis of 30 milligrammes of material, because it was found that three of the fireflies used weighed approximately 30 milligrammes. The hydrogen peroxide was prepared by diluting commercial hydrogen peroxide with an equal volume of distilled water. A full description of the method may be found in a previous publication.

Experiments.—Three fireflies previously ground up in a mortar with sand were introduced into a bottle containing 50 c.c. of hydrogen peroxide and the amount of oxygen liberated in 10 minutes was determined. Ten such determinations were made with an average of 118 c.c. of oxygen per 30 milligrammes of firefly. Similarly a moth ground up in sand was introduced into 50 c.c. of hydrogen peroxide and the amount of oxygen liberated determined. The average amount of oxygen liberated by moths was 8 c.c. of oxygen per 30 milligrammes of material. Determinations were also made using honey-bees, bumble-bees, and butterflies. The amount of oxygen liberated in none of these determinations exceeded 25 c.c. of oxygen per 30 milligrams of material. ,

Conclusions.—The catalase content of a luminous insect where oxidation is presumably more intense is greater than that of a non-luminous insect where oxidation is less intense.

W. E. BURGE

UNIVERSITY OF ILLINOIS

[1] From the Physiological Laboratory of the University of Illinois. From experiments carried out at Nela Research Laboratory.

[2] Dubois, "Mécanisme intime de la production de la lumière chez les organismes vivants," *Soc. Linneenne de Lyon, Imprimerie* A. Rey.

[3] Burge, *The American Journal of Physiology*, Vol. XLI., No. 2, August, 1916.

EFFECT OF SMELTER GASES ON INSECTS[1]

IT is often claimed that the waste gases, particularly sulphur dioxide, thrown off during the process of smelting copper, lead and some other ores, have a very decided influence on the number of insects in the vicinity of the smelters. Some believe that few if any

[1] Contribution from the laboratories of the American Smelting and Refining Co., department of agricultural investigations.

insects can live in such regions because of the baneful effect of the gases, others believe that insects are unusually abundant there, particularly in regions where more or less injury has been done to vegetation under conditions that formerly existed in some of the smelters. Bees are thought to be particularly susceptible to these gases and it is often claimed that their numbers are so reduced in smelter regions as to seriously affect the fruit crops because the flowers are not properly fertilized. There is no basis whatever for any such claims or beliefs. For several years I have spent all or part of each summer in studying the insects in regions where smelters are located and, for purposes of comparison, in similar adjacent regions, and in no instance have I been able to detect any differences in the number of insects or in the extent of insect injury, due to the presence of smelter gases.

During the last three years the Department of Agricultural investigations of the American Smelting & Refining Co. has carried on extensive series of experiments to test the effect of sulphur dioxide on various kinds of vegetation. As insects are often covered over by the cabinets when they are placed over the plots of grain or other vegetation for fumigating, I have had many opportunities to watch their behavior when subjected to known quantities of sulphur dioxide.

The cabinets used in these experiments were about six feet square and five feet high and were made of celluloid with a light framework of wood. Through these cabinets a current of air carrying a known quantity of sulphur dioxide was driven by means of electric fans. Every precaution was taken to see that the concentration of the gas was constant in all parts of the cabinet throughout the experiment. The time of fumigation varied from half an hour to two or three hours. In every experiment a check cabinet where conditions were exactly similar, except for the absence of the sulphur dioxide, was used. The following sets of definite experiments and observations were made in 1916.

A number of honey bees were placed in a cabinet where SO_2 was being introduced, the strength being 1 part of SO_2 to 1 million parts of air. During the half hour that they were submitted to the fumigation the bees behaved in the same way as did other bees placed in the check cabinet where no gas was being introduced.

In another experiment bees, butterflies, grasshoppers and mosquitoes were placed in the cabinet where 5 parts of SO_2 to 1 million parts of air was being introduced. The experiment was continued for one hour during which time the insects behaved in a normal way, some of the grasshoppers feeding during much of the time as contentedly as they would have fed outside of the cabinet. When the cabinet was removed the insects flew or hopped away and none showed any ill effects due to the confinement for one hour in this concentration of the gas.

At another time while fumigating some alfalfa plants with a very high percentage of SO_2, 25 parts of the gas to 1 million parts of air, I watched a number of insects that were on the plants in the cabinet. The alfalfa weevils, adults and larvæ, went on with their work undisturbed. Flies, mosquitoes, leafhoppers, grasshoppers and ladybird beetles, behaved in a perfectly normal way and at the end of the hour over which the experiment extended, it could not be seen that the fumigation had had any effect on them.

As the concentration of gas in the last experiment was several times as high as we should ever find in the field even quite near the smelters, it is safe to say that the sulphur dioxide given off by the smelters has no effect whatever on the insects in that region.

It is true that SO_2 generated by burning sulphur in a room or other enclosed spaces is sometimes recommended for killing insects. But this is used at the rate of 2 lbs. of sulphur for every 1,000 cubic ft. of space. At sea level and at 20° C. or 68° F. this would give a concentration of gas equal to 24,009 parts of gas to one million parts of air. Even at this rate with prolonged fumigations the insects are not always all killed!

R. W. Doane
Stanford University